

Death in the line of duty...



A summary of a NIOSH fire fighter fatality investigation

January 18, 2012

# Career Fire Fighter Dies in Church Fire Following Roof Collapse-Indiana

# **Executive Summary**

On June 15, 2011, a 40-year-old male career fire fighter (the victim) lost his life at a church fire after the roof collapsed, trapping him in the fire. At 1553 hours, the victim's department was dispatched to a report of a church fire at an unconfirmed address. Units arriving on scene observed visible flames and heavy smoke coming from the roof of the church. A second alarm was immediately requested due to the lack of hydrants in this area. Initially, the incident commander (IC) sent in a truck crew consisting of an officer and 4 fire fighters, followed by 2 fire fighters (including the victim) from the arriving engine company for search and suppression activities. The interior crew was initially met with visible conditions, light smoke, and no visible fire within the church. Conditions



Incident scene. (Photo courtesy of Star Press.)

quickly changed after walls and areas of the ceiling were opened, exposing a fire engulfed attic space. A decision was then made to evacuate the building due to the amount of fire burning above the fire fighters. At this same moment (approximately 1610 hours), the roof began to collapse into the church where the fire fighters were working, trapping the victim and injuring others as they exited out of windows or ran from the collapse. Due to the magnitude of the fire, the fire department was unable to return to the collapsed area to rescue the victim. The victim's body was later recovered after the fire was extinguished.

# **Contributing Factors**

- Initial size-up did not fully consider the impact of limited water supply, available staffing, the occupancy type, and lightweight roof truss system
- Risk management principles not effectively used
- High risk, low frequency incident
- Rapid fire progression

- Offensive versus defensive strategy
- Failure to fully develop and implement an occupational safety and health program per NFPA 1500
- Fire burned undetected within the roof void space for unknown period of time
- Roof collapse.

# **Key Recommendations**

- Fire departments should ensure that a complete situational size-up is conducted on all structure fires
- Fire departments should use risk management principles at all structure fires
- Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.



D-side of church following collapse and control of the fire. (Photo courtesy of fire department.)

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program Web site at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

## Introduction

On June 15, 2011, a 40-year-old male career fire fighter (the victim) lost his life at a church fire after the roof collapsed trapping him in the fire. On June 16, 2011, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. The NIOSH lead investigator contacted the fire department on June 16, 2011 regarding the incident. On July 10 through July 15, 2011, two safety and occupational health specialists from the NIOSH Fire Fighter Fatality Investigators met with the fire department's deputy chief, training officer, chief arson investigator, and battalion chiefs; representatives from the local fire fighters' union; a state fire marshal investigator; representatives with the Indiana Department of Labor; and 9-1-1 center personnel.

Interviews were conducted with fire fighters/officers directly involved with the incident, the local fire fighter's union president, the incident commanders (IC), and operation's staff. The NIOSH investigators visited, documented, and photographed the fire scene and structure. The NIOSH investigators reviewed photographs of the victim's personal protective equipment (PPE), self-contained breathing apparatus (SCBA), the fire's progression, and origin/cause investigation. The NIOSH investigators reviewed the victim's SCBA maintenance records, SCBA data logger information of two fire fighters with the victim at the time of the collapse, and death certificate. The NIOSH investigators also reviewed training records for the victim, both ICs, and fire fighters working with the victim at the time of the collapse; dispatch radio transcripts; videos; and department standard operating procedures (SOPs).

## **Fire Department**

At the time of this incident, this career fire department was operating from 5 fire stations with 103 uniformed members serving a population of over 67,000 within an area of about 39 square miles. The population could increase to over 85,000 when the local university is in session. The fire department had five engines (two of these were spare engines), two quints, two rescue trucks (one was a spare), and two aerial platform trucks (one was a spare). The city currently utilizes a county EMS service to provide medical care and patient transport where needed.

All field personnel worked a 24-hour duty shift (0700 to 0700) every other day for five days and then received 4 consecutive days off before repeating the schedule. The fire department operated with approximately 30 personnel on each of three operating tours, which routinely included 2 captains and 5 lieutenants. Currently, the fire department attempts to maintain four personnel per apparatus as their minimum staffing per apparatus, but the current union contract with the city only specifies that there be a minimum staffing of three personnel per apparatus. However, there is no overall per shift minimum staffing level. The last time that fire personnel were hired was prior to 2009.

The department currently has two certified incident safety officers (ISO), but no procedures are in place to have an ISO respond to fire incidents. The IC maintains this responsibility on the fireground unless he delegates this position to an individual on scene. Also, the roaming battalion chiefs are not afforded aides to assist them and no designated accountability officer is assigned.

Since 2007, the fire department has seen significant changes including three different fire chiefs, station closures, and fire fighter layoffs (June 2009). The fire chief position is appointed by the city mayor. The fire chief is tasked with appointing a deputy chief, chief fire investigator, and training officer. The ranks of battalion chief, captain, lieutenant, and sergeant are tested positions. The fire department employs a merit commission whose sole duties include overseeing the application/appointment to the fire department, prohibited political activity, discipline, past performance rating, promotion, and promotion eligibility of the fire and deputy chiefs. At the time of the incident, applicants for a higher position within the fire department did not have to meet any minimum requirements.

In 2009, the fire department was operating from seven fire stations with relatively the same amount of personnel on duty per shift. The layoff of 32 fire fighters lowered the department's staffing by one-third, well below the department's minimum staffing levels. One station became the department's training office while the other remained closed, which led to five operating stations at the time of the incident. The closed fire station was approximately 1½ miles from the incident. Prior to the reductions, the fire department was able to get at least 14 personnel on scene within 8 minutes, 86% of the time, but following the reductions, this response time was achieved only 39% of the time. In 2010, the department received a SAFER grant and was able to hire back 25 of the 32 laid-off fire personnel. The two fire stations have remained closed. *Note: Due to a flood in March 2011, an additional station was closed, but the apparatus and personnel were relocated into the station housing the training office.* According to fire department personnel, funding for day-to-day operations, response times, and personnel continue to be a problem.

The NIOSH investigators reviewed written fire department SOPs, rules, and/or regulations, that were provided to them, in the following areas:

- Incident Management System
- Discipline and conduct
- Reporting for duty
- Reporting an absence
- Bereavement
- Minimum staffing
- Assignments
- Responsibilities of station officers and driver/operators
- Daily station duties and rules
- Special daily duties
- Dress code
- Safety and health
- Responding to alarms
- Command
- Fire suppression
- Fire prevention
- Public relations

- Building security
- Parking
- Retirement

These written SOPs, rules, and/or guidelines are generic and provide minimum guidance. However, the department's SOP on incident management is very detailed and specific regarding incident command procedures. The department does not have written detailed SOPs covering such topics as incident safety officer, rapid intervention teams, mayday procedures, safety and health program, and engine or truck company operations.

# **Training and Experience**

The victim had been with this department for approximately 6 years. The victim was hired in 2005, after serving 15 years with a local volunteer fire department where he held the rank of fire chief for the last 5 years while with the volunteer department. He held certifications in Fire Fighter I and II, EMT-Basic, Fire Medic II, NIMS First Responder (Awareness and Operational levels), Rope Rescue (Awareness, Operations, and Technical levels) and Vehicle and Machinery Rescue (Awareness, Operations, and Technical levels). He had also completed documented yearly refresher training on topics such as heat emergencies, hazardous materials, SCBA, and aerial operations.

The lieutenant, assigned with the interior crew, had been with this department for approximately 17 years. He held certifications in Fire Fighter I and II, EMT-Basic, Fire Medic II, Instructor I, Fire Officer I, HAZMAT First Responder (Awareness and Operational levels), Rope Rescue (Awareness, Operations, and Technical levels), Swift Water Rescue (Awareness, Operations, and Technical levels), Vehicle and Machinery Rescue (Awareness, Operations, and Technical levels), Trench Rescue Awareness, Wilderness Rescue Awareness, Structural Collapse Awareness, Second Class Fire Fighter, and NIMS First Responder (Awareness, Operations, and Technical levels). He had also completed documented yearly refresher training on topics such as building construction and fire behavior, live fire training for lead instructors, aerial operations, confined space, and search/rescue. He had also completed documented courses on ICS such as IS-100 Introduction to the Incident Command System in 2006 (Federal Emergency Management Agency [FEMA]/Emergency Management Institute [EMI]), IS-200 ICS for Single Resources and Initial Action Incidents in 2006 (FEMA/EMI), IS-700 National Incident Management System in 2006 (FEMA/EMI), IS-800 National Response Plan, An Introduction in 2006, and ICS-300 Intermediate ICS for Expanding Incidents in 2008 (FEMA).

The IC, at the time of the incident, had been with this department for approximately 25 years, holding the rank of a captain. He held certifications in Fire Fighter I and II, Fire Investigator I, Fire Medic I, and NIMS First Responder (Awareness and Operational levels). He had completed documented yearly refresher training on topics such as building construction and fire behavior, aerial operations, confined space, hazardous materials, and aerial operations. He had also completed documented courses on the incident command system (ICS), such as IS-100 Introduction to the Incident Command System in 2006 (FEMA/EMI)), IS-700 National Incident Management System in 2006 (FEMA/EMI), IS-200 ICS for Single Resources and Initial Action Incidents in 2008 (FEMA/EMI), ICS-300 Intermediate ICS for Expanding Incidents in 2008 (FEMA), IS-800.B National Response Framework, An Introduction in

2008 (FEMA/EMI), and the state sponsored course Critical Decision Making and Public Safety – How to Make Better Decisions Under Pressure in 2011.

The acting battalion chief (BC), on scene at the time of the incident (who took command following the collapse), had been with this department for approximately 18 years. He held certifications in Fire Fighter I and II, EMT-Basic, Fire Investigator I, Fire Medic I, Instructor I, HAZMAT First Responder (Awareness and Operational levels), and NIMS First Responder (Awareness and Operational levels), the had also completed documented yearly refresher training on topics such as heat emergencies, hazardous materials, SCBA, and hose testing. He had also completed documented courses on ICS such as IS-100 Introduction to the Incident Command System in 2006 (FEMA/EMI)), IS-200 ICS for Single Resources and Initial Action Incidents in 2006 (FEMA/EMI), IS-700 National Incident Management System in 2006 (FEMA/EMI), and ICS-300 Intermediate ICS for Expanding Incidents in 2009 (FEMA). He had been a captain for the last four years leading up to the incident and had worked as an acting battalion chief the minimum of 16, 24-hour duty shifts each year.

This fire department does not have a formal fire recruit training academy for new hires. A candidate for this department could be hired with or without training. New hires without training are required to take a 40-hour, state-required training before starting work. This class is taught in house by fire department personnel. The new hires must also obtain their Fire Fighter I and II certifications within a year of hire in order to maintain their employment. While in training, these individuals are allowed to work but cannot enter a structure or hazardous environment. Regardless of level of experience and certifications obtained, new hires must be paired with seasoned fire fighters/officers for at least one year before being taken off probation. *Note: Individuals without any fire certifications must complete above training within a year*. The fire department also maintains a weekly and monthly training schedule to maintain fire fighter competency levels. These topics vary and may include medical topics, hazardous materials, special rescue types, aerial operations, and search/rescue.

## **Equipment and Personnel**

The initial dispatched (by radio) assignment included Truck 2 (T2), Rescue 2 (R2), Engine 3 (E3), Tower 3 (TW3), Engine 1 (E1), and the acting BC. *Note: TW3 was out-of-service, requiring the crew to take E2 (a spare) and E1 is actually Engine 6 (see note below).* The following units responded for the 1<sup>st</sup> alarm assignment:

- T2 (400 gallons of water) with a driver, two fire fighters (FF3 and FF4), and a captain(initial IC)
- R2 (250 gallons of water) with a driver, two fire fighters (FF1 and FF2), and a lieutenant
- Engine 2 (E2) (500 gallons of water) with a driver, the victim, and an acting lieutenant
- E3 (1,000 gallons of water) with a driver, fire fighter (FF5), and a lieutenant
- Engine 6 (E6) (1,000 gallons of water) with a driver, two fire fighters, and acting captain
  Note: E1 is actually E6 which was running out of station #1, after station #6 was flooded.
- Acting BC

The T2 officer (the initial IC) requested a  $2^{nd}$  alarm upon arrival to the incident. The following units responded for the  $2^{nd}$  alarm assignment:

- Engine 5 (E5) (500 gallons of water) with a driver, three fire fighters, and a lieutenant
- Truck 7 (T7) (400 gallons of water) with a driver, two fire fighters, and an acting lieutenant

#### Water Supply

The fire was located in a rural area, and no water hydrants were available in the immediate area surrounding the church. T2, with 400 gallons of water, was initially supplied by a 2½-inch supply line from E3, supplying them with an additional 1,000 gallons of water. E6 arrived on scene, pulled parallel to T2, and supplied T2 with another 1,000 gallons of water. A 2<sup>nd</sup> alarm and mutual aid tankers were requested by the IC upon his arrival, due to the lack of hydrants in the area. *Note: See Photo 1 for initial incident scene*.



Photo 1. Initial incident scene with available water supply on scene. (Adapted from Google Maps® satellite image.)

## Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded and intelligible radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. NIOSH investigators have attempted to include all intelligible radio transmissions, but some may be missing. This timeline is not intended, nor should it be used, as a formal record of events.

#### • 1549 – 1552 Hours

The dispatch center received numerous 911 calls for a church that appeared to be on fire. Callers described heavy smoke emitting from the eaves and from the top of the roof line.

#### • 1553 Hours

The dispatch center dispatched units T2, R2, E3, TW3, E1, and BC for the report of a church fire. The dispatcher advised units that several 911 calls had been received stating smoke was pouring from the roof, but an exact location was not known. "Fireground 1" was the incident channel.

#### • 1554 Hours

Dispatch updated units with a believed location of the incident. Additional 911 calls continued to come in indicating heavy smoke from the roof. T2, E3, and R2 en route.

#### • 1555 Hours

T2 asked, "Do we have an exact address yet?" Dispatch advised T2, "We have a possible...," and provides an address. E6, E2, and BC en route.

#### • 1557 Hours

T2 officer stated, "...will be arriving here shortly; we do have visible flames and heavy smoke...visible flames and heavy smoke; T2 will be command...T2 will be command; dispatch go ahead and make this a second alarm."

Dispatch copied stating, "T2 I'm clear, we have a fully engulfed church fire, and you need a second unit. BC can you advise who you want?"

The BC advised dispatch to send stations 5 and 7 and notify the fire chief.

#### • 1558 Hours

Ambulance dispatched and en route to the incident.

#### • 1559 Hours

Stations 5 and 7 dispatched to the incident.

#### • 1600 Hours

E5 en route. E6, R2, and BC on scene.

#### • 1601 Hours

T7 en route.

IC requested a mutual aid alarm for tankers and the training officer to bring the department's reserve tanker.

#### • 1604 – 1605 Hours

Interior crew possibly made entry about this time.Mutual aid Tanker 55 dispatched and en route.Mutual aid Tanker 73 dispatched.Dispatch advised IC that two mutual aid departments had been dispatched and asked whether he needed additional units from other mutual aid departments.The IC advised dispatch to notify additional departments for their tankers.E3 and E2 on scene.

#### • 1606 Hours

Mutual aid Tanker 73 en route. Ambulance on scene.

#### • 1607 Hours

Mutual aid Tanker 44 dispatched and en route.

#### • 1608 Hours

A second county ambulance is dispatched and en route Dispatch received a 911 call stating the next door neighbor had a pond available for water; relayed to IC and copied.

#### • 1609 Hours

R2 officer, within the church sanctuary, asked the IC if they had a water supply established yet because they weren't doing well with the  $1\frac{3}{4}$ -inch and with this much fire. The IC advised R2 officer to go ahead and back out a little bit.

R2 officer advised the IC that they are going to pull out of the structure; IC acknowledged.

#### • 1610 – 1615 Hours

Unintelligible distress radio transmission from interior crew. Yelling is heard along with possible audio of the collapse. Interior crew members escape through windows and/or follow hoseline out of sanctuary to safety.

BC took over as IC, requested EMS and assigned the T2 officer (the initial IC) with search and rescue for the victim. *Note: The interior crew members responded back to the command post and determined that the victim was unaccounted for.* 

E5 on scene.

IC and E5 have conversation on where E5 should position their apparatus.

Over the radio, the IC requested E5 and T7 personnel to come to the front of the building, packed up and ready, because they had a fire fighter down; E5 and T7 acknowledged. IC and dispatcher have conversation about sending all available tankers in the area to the incident.

IC advised dispatch to notify Unit 101 of a fire fighter down and missing.

- IC attempted to contact the victim over the radio without any response.
- T7 on scene.

E6 officer advised T2 officer and IC, "...we can see in, whole church is down...we got a pile of rubble probably 3 feet deep and it's all on fire; we can't see anything; we're going to have to wait to get it out before we can go through it."

All fire fighters removed from structure and defensive actions taken.

• 1704 Hours

News helicopter flying over the incident scene locates the victim within the debris.

# **Personal Protective Equipment**

It was reported to NIOSH investigators that the victim entered the structure wearing a full array of personal protective clothing and equipment, consisting of turnout gear (coat and pants), helmet, gloves, boots, hand-held radio, and a SCBA with an integrated PASS device, Nomex® hood and helmet. The victim's facepiece was properly connected to his regulator and was reported to be appropriately positioned about the face of the victim prior to the collapse.

The victim's SCBA and PPE was either consumed or severely damaged due to the long exposure to fire. Due to the severely deteriorated condition of the SCBA and PPE, no evaluation was conducted by NIOSH's National Personal Protective Technology Laboratory.

## Structure

The fire occurred within the attic space of a church sanctuary constructed in 1991. The sanctuary measured approximately 50 feet by 84 feet and contained wood frame construction with a brick veneer finish that was situated on a concrete slab (see Photo 2). The interior of the sanctuary had been completely consumed by the fire following the collapse (see Photo 3 and Diagram 1). The interior walls and ceilings were reported to have been covered with drywall with vaulted ceilings containing suspended lighting, speakers, and fans (see Photo 4). The interior contained several rows of wooden pews or chairs, a wooden pulpit, and music equipment situated on a carpeted floor. The lightweight roof truss system, believed to be 2- by 4-inch and 2- by 6-inch lumber connected with gusset plates, spanned the width of the sanctuary and ran the length of the sanctuary. A 3- to 4-foot void space, with blown-in insulation, existed between the ceiling and roof. *Note: Much of the roof truss system was consumed by the fire and exterior load bearing walls had collapsed or had crumbled prior to the NIOSH investigation.* At the south end of the church, a steeple rested atop the sanctuary's roof (see Photo 2). The roof was covered with asphalt shingles. The sanctuary did not contain a sprinkler

system but did have working fire-alarm pull stations. It is believed that at the time of construction, local building codes did not require the sanctuary to have a sprinkler system. The fire department had not pre-planned the church complex, but was aware that this area did not contain hydrants that could be used for fire suppression.



Photo 2. Aerial view of structure and property. The family center was not affected by the fire. The fire department was able to stop the fire's progression within the connecting hallway. Arriving from the south afforded incoming units with a 360 degree view of the complex. (Adapted from Google Maps® satellite image.)



Photo 3. Picture taken from the D-side of the structure showing the remains of the sanctuary. (NIOSH photo.)



Photo 4. Interior view of sanctuary where fire fighters would have been working. (Photo courtesy of church's website.)

#### Weather

The incident occurred during the day with temperatures outside ranging in the 60s. The area had seen thunderstorms during the day prior to the fire incident. Wind was coming from the south/southeast at 10 - 15 miles per hour during the incident, which NIOSH investigators believed played a role in fueling and pushing the fire through the attic space, once the sanctuary self-vented and after the roof of the connecting hallway was vented. Research by the National Institute of Standards and Technology has shown wind speeds on the order of 10 to 20 mph (16 to 32 km/hr) are sufficient to create wind-driven fire conditions in a structure with an uncontrolled flow path (http://fire.nist.gov/bfrlpubs/fire09/art015.html).

## Investigation

On June 15, 2011, at 1553 hours, the victim's department was dispatched for the report of a church fire. The units responding for the initial alarm included E2, E3, E6, T2, R2, and the on-duty BC. T2 responded from the west, coming around the C-side (south end) of the church before pulling into the

parking lot, which was located on the A-side (north end) of the church. This approach to the scene afforded arriving units a 360 degree view of the complex. The T2 officer noted smoke coming from the roof and flames emitting from the gables on the C-side. Other fire fighters from T2 described conditions as heavy black smoke from the roof with flames visible from the C-side gables. The T2 officer immediately transmitted his size-up, asked for a second alarm, and established himself as the IC. *Note: The IC could not remember if the steeple was still standing on the south end of the roof (C-side) at this time. A walk around of the church was not conducted by this IC.* Arriving personnel on E6 noticed smoke and flames coming from the roof upon their arrival. Fire fighters from R2 stated fire and smoke was visible from the C-side gables and roof. The BC advised NIOSH investigators that upon driving up to the scene, he observed that the steeple was still standing with fire visible from the C-side gables with smoke coming from around the steeple, but smoke was heavier from the eaves. *Note: Fire fighters interviewed do not recall seeing non-emergency vehicles parked at the church that would have indicated that the church might have been occupied at the time of the incident.* 

T2 was positioned in the parking lot in front of the entrance closest to the sanctuary. E6 pulled parallel to T2 facing the opposite direction, while R2 and the BC pulled into the parking lot away from suppression units. The driver of R2 placed an orange cone in front of this entry to signify the command post and the accountability tag drop point (all interior and roof personnel dropped their tags at the command post before entry). The church was secured, requiring a door on the A-side to be breached. After FF1 breached the entry door with a 6-foot pike pole, the R2 officer and four fire fighters (FF1 and FF2 from R2 and FF3 and FF4 from T2) made the initial entry into the sanctuary bringing with them a charged, single, 200-foot section of 1<sup>3</sup>/<sub>4</sub>-inch hoseline from T2 (see Photo 5). *Note: No additional equipment was initially brought in with them, such as a thermal imaging camera.* Two fire fighters from E6 were tasked by the BC with cutting a ventilation hole (trench cut) as close as possible to where the connecting hall roof met with the sanctuary roof, being sure to sound the roof as they got closer to the sanctuary (see Photo 5).



#### Photo 5. Aerial view of church complex focusing on where the ventilation hole was cut in relation to where fire and smoke were observed upon arrival and where interior fire fighters were working.

#### (Adapted from Google Maps<sup>®</sup> satellite image.)

The driver from R2 laddered the connecting hall with a 20-foot ladder, just left of where the fire fighters had made entry. The roof crew grabbed a roof saw and ascended the ladder to scope out a location for the cut. Once positioned on the roof, the E6 fire fighters made a 5 foot by 18 inch cut, but were only able to initially remove a section measuring approximately 12 inches by 12 inches (cut made over rafter). A second 1<sup>3</sup>/<sub>4</sub>-inch hoseline was deployed from T2 for the roof crew to use in case they were met with fire. The BC then began a walk around of the church complex going counterclockwise from the command post on the A-side.

The initial interior crew indicated that visibility was good throughout the sanctuary (light haze at ceiling level) as they spread out. FF3 stretched the hoseline along the B-side wall of the sanctuary all the way until he reached the raised platform (pulpit area) situated in front of the C-side wall (where fire had been visible from the exterior) (see Diagram 2). FF2 assisted in pulling in additional hose for FF3,

from the entry door, before exiting the structure to retrieve a flashlight. At the same time, E3 and E2 arrived on scene and observed heavy, black smoke and visible fire that had vented on the south end of the roof. *Note: It is unclear if the steeple had toppled over at this point*. While stretching the hoseline, FF3 observed FF1 open up a small portion of the C-side wall (in the area of the C/D corner) and ceiling that exposed a substantial amount of fire (area above and behind the raised platform), which FF3 attacked with the 1¾-inch hoseline until he reached the area behind the raised platform with FF1. FF2 reentered the structure to assist in finding an attic access. The R2 officer met FF1 and FF3 behind the raised platform (C/D corner), and they decided an attic ladder was necessary to better access the fire. FF4 exited momentarily to retrieve an additional pike pole to help FF1. When FF4 returned with the pike pole, FF5 and the victim had been ordered by the IC (T2 officer) to follow the hoseline in and see if the initial interior crew needed any assistance. FF4 exited the church again to retrieve an attic ladder. FF5 stated that, when they entered the sanctuary, there was light white smoke and they could not see the C-side wall from the initial entry point.

Before turning the corner to look at the C-side of the sanctuary, the BC was met by the E6 officer at the C/D corner where they observed the steeple tilting onto the sanctuary roof (see Photo 6). *Note: The BC stated he observed the steeple fall and immediately attempted to call the IC over the radio and advise him of this, but no radio traffic was heard or recorded on the 911 transcripts.* Following his attempts to contact the IC over the radio, the BC immediately walked back to the command post to speak with the IC regarding the integrity of the roof.



#### Photo 6. Steeple has toppled over onto the roof and it has begun to collapse into the roof system. The roof has not yet collapsed into the sanctuary. (Photo courtesy of Star Press.)

While waiting for the attic ladder, FF3 and FF1 took turns operating the hoseline toward the ceiling in an attempt to control the fire. FF5 and the victim noticed fire coming from recessed lighting within the ceiling above them. The victim stated to FF5, "This could get bad really quick." Once the attic ladder was delivered to the raised platform, a small portion of the ceiling fell into the sanctuary hitting FF2, exposing heavy amounts of fire above the ceiling level that was too much to be handled with the single hoseline. The victim stated to FF5, FF2, and FF4, "We need to get out now." At approximately the same time, the R2 officer had a brief conversation with the IC (over the radio) about backing out of the structure. Almost simultaneously, a large section of the ceiling/roof collapsed into the sanctuary where FFs 2, 4, 5 and the victim were standing. At the time of the collapse, fire pushed through the ventilation hole recently cut by E6 fire fighters. The roof crew was unaware that the sanctuary roof had started to collapse. They had to be ordered off the roof by the BC and driver of E6.

At the time of the collapse, the R2 officer was standing with FF1 and FF3 (close to the C/D corner) (see Diagram 3). The sanctuary became engulfed with fire, burning debris, and extreme heat. The R2

officer was knocked down by falling debris and visibility quickly became zero. FF1 was separated from the R2 officer and FF3; FFs 2, 4, 5, and the victim, standing in front of the raised platform (see Diagram 3), were all separated following the collapse. FF3 assisted the R2 officer in getting up. They did not observe any other fire fighters close to them. FF5 managed to make it to a B-side window, which he broke and escaped through the opening (see Photo 7 and Diagram 4). FF5 stated to NIOSH investigators that he immediately looked back to see if any fire fighters had followed him out, but no one appeared. FF3 and the R2 officer felt their way along the D-side wall until they found a window, which they broke and exited through (see Diagram 4). FF1, FF2, and FF4 made their way crawling over and through church pews and fire debris until they were able to exit through the initial entry door to the command post (see Diagram 4). They all quickly checked in with the IC, where they were notified that the victim was unaccounted for.



Photo 7. Photo shows FF5 looking back through the window on the B-side that he exited through following the initial roof collapse. Note the condition of the roof. (Photo courtesy of Star Press)

The T2 officer relinquished command to the BC and took over responsibilities for search and rescue of the victim. The IC advised E5 and T7 upon their arrival that they were to report with personnel to the command post as the rapid intervention team. Fire fighters re-entered the structure from different directions to search for the victim (family center, connecting hallway, and exterior of complex). Radio communications regarding responding tankers and positioning apparatus continued over the fireground channel. FF2, the driver of R2, and the E3 officer advanced a 1¾-inch hoseline (hoseline from the

roof) through the initial entry door to the opening into the sanctuary where they were met with another collapse of the roof and fire debris throughout the sanctuary. Entry into this area was deemed unsafe and the IC ordered all fire fighters to evacuate the entire structure. The driver of T2 was ordered by the BC to sound his air horn to notify fire fighters to evacuate. Fire fighters searched around the building and checked the connecting hall and family center for the victim, but he remained missing within the sanctuary. *Note: See Photo 8 and Photo 9 for conditions during search operations for the victim.* 



Photo 8. Fire fighters beginning their initial search and rescue into the building through the Aside forced entry door in an attempt to locate the victim. (Photo courtesy of Star Press.)



Photo 9. Photo shows the secondary collapse of roof into sanctuary area while search and rescue crews were inside the building. (Photo courtesy of Star Press.)

#### **Fire Origin/Cause and Behavior**

State and federal fire/arson investigators investigated the origin and cause of the fire. These investigators determined that the electrical and gas utilities had been damaged by fall down from the fire. They also received information from a passer-by who had observed the church being struck by lightning around 1045 hours on the day of the incident. Light smoke around the south end of the church was observed by this individual at this time. At approximately 1545 hours, this same individual passed by the church again and observed light smoke around the roof of the church (south end). The arson investigators took possession of what was believed to be part of the steeple, pieces of copper grounding wire, and metal rod (believed to be the lightning rod) and transported these items to their lab for further evaluation. At the time of this report, it is believed that the fire originated from a lightning strike to the steeple which grounded through the copper grounding wire placed within the attic and possibly down the C-side interior wall.

It is believed the fire then smoldered in the attic void (below the steeple) until combustible materials

within the attic reached their ignition temperature. It is believed that this void area only contained blown in insulation and no other stored combustible items. Within the sanctuary, below where the steeple would have been situated (south end), fire fighters were able to open the ceiling and view heavy fire conditions and "blue skies," indicating that the roof was failing and the steeple had already toppled over from its vertical position (see Photo 10). *Note: Wind appeared to be a factor in pushing and feeding the fire.* At the same time, fire fighters were also making a ventilation hole where the connecting hallway met the northeast corner of the sanctuary (see Photo 9). Fire then quickly spread into this voided area when fresh air was introduced (see Photo 11, Photo 12, and Photo 13). *Note: It is believed that the hallway connector and sanctuary shared a "common attic."* 



Photo 10. Steeple is lying on top of the sanctuary roof directly above where the fire fighters are working. Note column of smoke blowing toward the D-side of the structure and not flowing directly up. (Photo courtesy of Star Press.)



Photo 11. Photo shows the steeple has collapsed and the ventilation hole emitting smoke. (Photo courtesy of fire department.)



Photo 12. From the B/C corner, roof has collapsed into the sanctuary. Note fire blowing from the ventilation hole. (Photo courtesy of the Star Press.)



Photo 13. From the A-side of the complex, fire fighters gathered around initial entry point preparing for search and rescue of the victim. Note wind pushing smoke away from the building. (Photo courtesy of Star Press.)

## **Contributing Factors**

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that led to the fatality and injuries:

- Initial size-up did not fully consider the impact of limited water supply, available staffing, the occupancy type, and lightweight roof truss system
- Risk management principles not effectively used
- High risk, low frequency incident
- Rapid fire progression

- Offensive versus defensive strategy
- Failure to fully develop and implement an occupational safety and health program per NFPA 1500
- Fire burned undetected within the roof void space for unknown period of time
- Roof collapse.

## **Cause of Death and Injuries**

According to the death certificate, the coroner listed the victim's cause of death as due to smoke inhalation.

#### Recommendations

# Recommendation #1: Fire departments should ensure that a complete situational size-up is conducted on all structure fires.

Discussion: Among the most important duties of the first officer on the scene is conducting an initial 360 degree situational size-up of the incident. A proper size-up begins from the moment the alarm is received, and it continues until the fire is brought under control either offensively or defensively. The size-up should include an evaluation of factors such as the following:

- Location and volume of the fire
- Required fire flow
- Building construction
- Commercial versus residential structure
- Water supply
- Length of time the fire has been burning, recognizing burn time may have affected structural stability
- Conditions on arrival
- Occupancy
- Fuel load
- Presence of combustible or hazardous materials
- Exposures
- Roof and wall loads
- Time of day
- Available staffing on scene or en route
- Weather conditions
- A realistic evaluation of the ability to conduct an offensive attack with available resources.<sup>1.2</sup>

Even before the IC takes command of an incident he will be faced with having to determine what critical tasks must be performed to bring the incident under control, and whether he can handle delegating these tasks before becoming overwhelmed. The IC may need to consider assigning an

individual to be his aide or operations sector so that critical tasks can be delegated, carried through, and effectively supervised. The IC will use current knowledge and previous experience to formulate a plan for his arriving apparatus and personnel. When the IC arrives, he needs to ascertain as much information as possible to make a determination whether his plan will still work. The IC may be faced with several priorities, such as an entrapped civilian, an incident of a larger scale than previously determined, and the fire environment itself. This is additionally part of the initial situational size-up, which will constantly change as the incident progresses until it is brought under control. The IC should be willing to prioritize and change his strategy and plan based on these assessments. Most importantly, the initial size-up provides a starting point for all fireground operations.

During this incident, the initial arriving officer took command and placed his command post directly outside the initial entry door on A-side. Arriving from the south afforded incoming units a quick 360 degree view of the complex. He had an initial view of fire conditions on the C-side when he arrived from the south, but no conditions could be viewed once positioned on the A-side. Fixed command posts should be established in positions that provide the IC with the widest possible field of view of the incident scene. When the IC's view is blocked by obstacles like apparatus positioning, structures, or geography, he should quickly assign divisions and groups that can provide the necessary feedback to manage the incident. After arriving on scene and establishing the command post, the initial IC did not conduct a full 360 degree size-up. When the acting BC arrived on scene, he began a walk around of the structure where he discovered that the steeple had toppled over, indicating the potential for further collapse of the roof structure. The initial size-up failed to identify proper strategy and tactics for a large non-residential structure, location and volume of fire hidden above the fire fighters in the attic void space, a viable water supply for suppression, and hazards associated with lightweight roof truss systems.

Fire departments should be aware of the 2010 International Association of Fire Chiefs' (IAFC) *Rules of Engagement (ROE) of Structural Firefighting.*<sup>3</sup> These guidelines recommend that ICs conduct or obtain a 360-degree situational incident size-up, determine the occupant survival profile, and conduct an initial risk assessment.

#### Recommendation #2: Fire departments should use risk management principles at all structure fires.

Discussion: While it is recognized that fire fighting is an inherently hazardous occupation, risk management principles established by the fire service are based on the philosophy that greater risks will be assumed when there are lives to be saved and the level of acceptable risk to fire fighters is much lower when only property is at stake. Interior offensive fire fighting operations can increase the risk of traumatic injury and death to fire fighters from structural collapse, burns, and asphyxiation. Established risk management principles suggest that more caution should be exercised in abandoned, vacant, and unoccupied structures and in situations where there is no clear evidence indicating that people are trapped inside a structure and can be saved.<sup>1</sup> The IC, with input from the assigned ISO and/or division/group supervisors, is responsible for evaluating conditions at a structure fire and determining safe tactics for fighting the fire. To accomplish this, the IC should use a standardized strategic decision-making model. First, the IC should size up the critical fireground factors.<sup>2</sup> Before

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ordering an offensive attack, the IC must make a determination that offensive (interior) operations may be conducted without exceeding a reasonable degree of risk to fire fighters and must be prepared to discontinue the offensive attack if the risk evaluation changes during the fire fighting operation. A full range of factors must be considered in making the risk evaluation, including (but not limited to) the following:

- Presence of occupants in the building
- A realistic evaluation of occupant survivability and rescue potential
- Size, construction, and use of the building
- Age and condition of the building
- Nature and value of building contents
- Location and extent of the fire within the building
- Adjacent exposures (structures)
- Fire involvement or compromise of the building's structural components
- Residential or commercial structure
- Delayed discovery/reporting and its effect on burn time and structural stability
- Considerations of fire loading and fire behavior
- A realistic evaluation of the ability to execute a successful offensive fire attack with the resources that are available.  $\frac{1.2}{2}$

These fireground factors must be weighed against the risk management plan. Fire fighters are routinely exposed to certain known and predictable risks while conducting operations that are directed toward saving property. The IC is responsible for recognizing and evaluating those risks and determining whether the level of risk is acceptable or unacceptable. However, risks taken to save property should always be lesser than those to save lives.  $\frac{1.4}{1.4}$  Risks to fire fighters versus gains in saving lives and property must always be considered when deciding whether to use an offensive or defensive attack. The IC should routinely evaluate and reevaluate conditions and radio progress reports in reaching objectives to dispatch and on scene fire fighters. This process allows the IC to determine whether to continue or revise the strategy and attack plans. Failure to revise an inappropriate or outdated attack strategy is likely to result in an elevated risk of death or injury to fire fighters.  $\frac{2.5}{2.5}$ 

Retired New York City Deputy Fire Chief Vincent Dunn states the following: "When no other person's life is in danger, the life of the firefighter has a higher priority than fire containment."<sup>6</sup> Chief Dunn also states "The protection of life is the highest goal of the fire service...When a life is clearly threatened; there is no risk too great. At most fires, however, lives are not clearly endangered. At most fires, then, the priority of fire fighting is the protection of the fire fighters' lives." In general terms, the risk management plan must consider the following: (1) risk nothing for what is already lost—choose defensive operations; (2) extend limited risk in a calculated way to protect savable property—consider offensive operations; (3) and extend very calculated risk to protect savable lives—consider offensive operations.<sup>1,3</sup>

NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, Chapter 8.3 addresses the use of risk management principles at emergency operations. Chapter 8.3.4 states that

risk management principles shall be routinely employed by supervisory personnel at all levels of the incident management system to define the limits of acceptable and unacceptable positions and functions for all members at the incident scene. Chapter 8.3.5 states that at significant incidents and special operations incidents, the incident commander shall assign an incident safety officer who has the expertise to evaluate hazards and provide direction with respect to the overall safety of personnel. The annex to Chapter 8.3.5 contains additional information.<sup>5</sup>

Modern incident demands on the fireground, unlike those of the recent past, require ICs and commanding officers to have increased technical knowledge of building construction with a heightened sensitivity to fire behavior, a focus on operational structural stability, and considerations related to occupancy risk versus the occupancy type. Strategies and tactics must be based on occupancy risk, not occupancy type, and must have the orchestration of sufficient staffing, fire flow, and tactical patience in a manner that identifies with the fire profiling and the predictability of the occupancy profile and accounts for presumptive fire behavior.<sup>7</sup> The first arriving officer, as well as the IC, must make a judgment as to what is at risk – people or property. This judgment will determine the risk profile for the incident. Many fire fighters stand by the notion that all incidents are "people" events until proven otherwise. Historically, the fire service has a poor history of changing risk-taking strategies based upon the people/property issue.<sup>8</sup>

In this incident, the parking lot was vacant and the complex was secured, requiring the church doors to be breached. The volume of fire discovered in the attic was too large for the initial 1<sup>3</sup>/<sub>4</sub>-inch hoseline and not easily accessible by the fire fighters. Also, the fire department did not have sufficient water and significant fire flow to extinguish a fire in a nonresidential structure and of the volume of fire encountered.

# *Recommendation #3: Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.*

Discussion: NFPA 1620 *Standard for Pre-incident Planning* states, "The purpose of this document shall be to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment." A pre-incident plan identifies deviations from normal operations and can be complex and formal or simply a notation about a particular problem, such as the presence of flammable liquids, explosive hazards, lack of hydrants, modifications to structural building components, or structural damage from a previous fire.<sup>9-11</sup>

Building characteristics including type (or more importantly risk) of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics should be recorded, shared with other departments who provide mutual aid, and, if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address. <sup>11</sup> These pre-incident plans can help determine safety hazards within or around a structure, length of response times, and locations of closest hydrants. Since many fire departments have tens/hundreds of thousands of structures within their jurisdiction, it is a challenge to establish an

effective preplanning system. Priority should be given to those having elevated or unusual fire hazards, being a high risk and low frequency type incident, and life safety considerations.

During NIOSH interviews, fire fighters involved with the incident were aware that this area did not have an immediate water supply and that the church had not been preplanned prior to the fire.

# **Recommendation #4:** Fire departments should ensure that a viable water supply and adequate fire flow is established prior to committing interior crews for fire suppression operations.

Discussion: Establishing adequate water supply on the fireground is one of the most critical elements of fire fighting. It is important in areas with a water distribution system and even more critical in areas where water must be supplied.  $\frac{12.13}{12}$  An assessment and decision of suppression methods must be made before attacking a fire in hopes of extinguishing it and keeping fire fighters safe while doing so. To accomplish such tasks, ICs, officers, and fire fighters must consider factors such as fire load and flow, hose and nozzle selection, placement and use of fire streams, and required staffing. Fire load (or heat released from combustible materials) will directly affect how the fire develops throughout the incident and how long and severely it may burn. The more combustible materials involved, the greater the heat that will be produced, requiring additional fire flow. Fire flow is the calculated amount of water in gallons per minute needed to extinguish a fire in a specific structure. To assist fire fighters in calculating the fire flow, one of three formulas could be used: the Iowa Rate-of-Flow Formula, the National Fire Academy (NFA) Formula, and the Insurance Services Office Formula. The Iowa Rateof-Flow Formula and NFA Formula were designed to be used on the fireground because they allow fire fighters to mentally compute the fire flow with relative ease by estimating such things as the square footage (area) of a structure or the cubic footage (volume) of a room, and percentage involved then inputting that data into a predetermined formula.<sup>1</sup>

The fire stream, or water stream, is an important aspect both for fire fighter safety and tactical considerations. The wrong choice of fire stream can place a fire fighter and crew in a bad situation. Also, the wrong type of fire stream will affect the tactical outcome of the incident in regards to how quickly the fire is controlled. To produce an effective fire flow, there must be a viable water supply; sufficient water pressure; a means to transport the stream to the desired point (fire); and trained, competent personnel to deploy these three elements.<sup>14</sup> These elements are applied through the use of a fire hose and nozzle. The diameter of the fire hose can affect how much water is flowed on a fire, but the larger the diameter, the more potential to max out the delivering pump's capacity, and additional personnel will be needed to handle the hoseline. The nozzle will allow the water to leave its mechanical hold within the hoseline to produce the desired fire stream. Typical fire streams include solid, fog, and broken, and each have their own characteristics, advantages/disadvantages, and application. Proper training on all these aspects will greatly influence fire fighter's knowledge on the fireground, provide for quicker control and extinguishment of the fire, and increase overall fire fighter safety.

# Recommendation #5: Fire departments should be aware of potential hazards associated with lightweight wood truss structures that have been exposed to fire for an extended period of time and acknowledge the potential for a collapse within a structure.

Discussion: During fire operations, two rules exist about structural collapse: (1) the potential for structural failure always exists during and after a fire, and (2) a collapse danger zone must be established.<sup>9, 15-17</sup> Buildings or structures within a building can collapse due to the structural damage directly caused by a fire or the activities of fire fighting operations (e.g., pulling ceilings, roof ventilation, and water application). This is especially true in lightweight-type construction. Other factors may include roof loads, fuel loads, damage, renovation work, pre-existing deterioration, water load, support systems, and truss construction.<sup>6, 18-19</sup> A collapse is a possibility after fire involvement of more than 10 minutes, but fire departments should not rely solely on time as a collapse predictor.<sup>19</sup>

If fire is not venting through the roof, interior fire suppression crews must act quickly in exposing concealed spaces such as walls, soffits, and drop ceilings, so that the seat of a fire and its spread can be quickly contained and extinguished through coordinated water application. Opening up concealed spaces will also provide interior fire suppression crews a good view of structural/support components in order to assess any damage or instability. This assessment will assist the fire department in making a decision to manage the fire offensively or defensively, to designate a safety officer, and whether or not to establish a collapse zone.

Exterior fire personnel such as the ISO, ventilation crews, or the IC should be evaluating a structure for potential collapse as well. They should be observing visible fire and wind conditions, dead loads on roofs (e.g., air handling units or steeples), and visible instability of exterior load-bearing walls. Whether interior or exterior, all observations needed to be immediately passed on to the IC, so that a decision can be made to continue the current fire attack strategy or make a change. During this incident, the interior crew had difficulty finding an attic access where they could view the extent of fire. They were unaware of just how much fire was located above them. When they observed blue skies from within the sanctuary, this indicated the roof system was severely compromised.

Maintaining situational awareness at all times during a fire incident is paramount. Situational awareness is a highly critical aspect of human decision making: understanding what is happening around you, projecting future events, comprehending information and its relevance, being realistic, and an individual's perception.<sup>20</sup>Fire fighters, officers, and incident commanders must be able to make critical decisions based on their knowledge, experience, and observations so that fire fighter health and safety is achieved. In this incident, the age/type of construction and no internal supporting columns were indicators that should have suggested the possibility of lightweight wood trusses being used in the roof system.

# Recommendation # 6: Fire departments should develop, implement and enforce written standard operating procedures (SOPs) for an occupational safety and health program in accordance with NFPA 1500.

Discussion: The risk for fatal injury among fire fighters is high compared to other occupations.<sup>21</sup> An increasing body of scientific literature demonstrates that organizational practices are effective in reducing worker injuries when top level management is committed to safety by establishing and fostering compliance with safety policies and practices and involving workers in identifying safety hazards and promoting solutions are.<sup>22-27</sup> Many of these concepts are embodied in NFPA 1500 *Standard for a Fire Department Occupational Safety and Health Program*.<sup>5</sup> Implementation of a strong fire department occupational safety and health program following written procedures and policies such as those outlined by NFPA 1500 can foster and improve the overall safety climate of a fire department, as well as improve specific safety and health areas, such as respiratory protection, risk management, training and competency in fireground operations, tactics, and equipment and apparatus use.

During this investigation, NIOSH investigators reviewed written departmental SOPs. While these documents contained some individual SOPs and policies, they mainly contained administrative guidelines and did not contain detailed fireground operational procedures that would enhance fire fighter safety and health, such as a risk management plan, a fire department occupational safety and health policy, and other components of a fire department occupational safety and health program as outlined in NFPA  $1500.^{5}$ 

A department policy is a guide to decision-making that originates with or is approved by top management in a fire department. Policies define the boundaries within which the administration expects department personnel to act in specified situations. A procedure is a written communication closely related to a policy. A procedure describes in writing the steps to be followed in carrying out organizational policies. SOPs are methods or rules in which an organization or a fire department operates to carry out a routine function. Usually these procedures are written in policies and procedures handbook and all fire fighters should be well versed as to their content.<sup>28</sup> Operational procedures establish accountability and increase command and control effectiveness when they are standardized, clearly written, and mandated to each department member.<sup>28</sup> The benefits of having clear, concise, and practiced SOPs are numerous. For example, they can become a training outline and a tool to guide fire department members. Above all, a well-applied SOP improves departmental safety.<sup>15</sup>

# Recommendation #7: Fire departments should train fire personnel to communicate interior and exterior conditions to the incident commander as soon as possible and to provide regular updates.

Discussion: Proper size-up and a risk-versus-gain analysis require that the IC have a number of key pieces of information and be kept informed of the constantly changing conditions on the fireground. The IC must develop and use a system that captures pertinent incident information to allow continuous situational evaluation, effective decision making, and development of an incident management structure. Decisions can be no better than the information on which they are based. The

IC must use an evaluation system that considers and accounts for changing fireground conditions in order to stay ahead of the fire. If this is not done, the incident action plan (IAP) will be out of sequence with the phase of the fire, and the IC will be constantly surprised by changing conditions.<sup>9, 17, 29</sup> Interior size-up is just as important as exterior size-up. The BC and E6 officer observed the steeple toppling onto the roof, but that radio traffic was not heard by the IC. Since the IC is staged at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the IC.

Interior conditions could change the IC's strategy or tactics. Interior crews can aid the IC in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates. During this incident, no reports were made to the IC on initial interior conditions, sudden changes to conditions, or attic access problems. According to Chief Dunn, construction features that could hide void spaces (e.g., drop ceilings, void spaces, and other features<sup>19</sup>) should be immediately communicated to the IC. Also, NFPA 1500, Chapter 8.2, Communications, section 8.2.1, states that the fire department shall establish and ensure the maintenance of a fire dispatch and incident communications system that meets the requirements of NFPA 1561 *Standard on Emergency Services Incident Management System*<sup>30</sup> and NFPA 1221 *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*.<sup>31</sup>

Chief Brunacini states that critical fireground factors, including interior and exterior conditions, are among the many items that the IC must consider when evaluating tactical situations. These items provide a checklist of the major topics involved in size-up, decision making, initiating operations, and review and revision. The IC deals with these critical factors through a systematic management process that creates a rapid, overall evaluation; sorts out the critical factors in priority order; and then seeks out more information about each factor. The IC must train and prepare (through practice) to engage in conscious information management. Incident factors and their possible consequences offer the basis for a standard incident-management approach. A standard information approach is the launching pad for effective incident decision making and successful operational performance. The IC must develop the habit of using the critical factors in their order of importance as the basis for the specific assignments that make up the IAP. The IC must create a standard information system and use effective techniques to be kept informed at the incident. The IC can never assume the action-oriented responder engaged in operational activities, will stop what they are doing so they can feed the IC with a continuous supply of top-grade objective information. It is the IC's responsibility to do whatever is required to stay effectively informed.<sup>32</sup>This may include requesting periodic updates from interior and/or exterior crews.

# **Recommendation #8: Fire departments should familiarize and continually train all personnel in building construction types and safety considerations.**

Discussion: A fire department's familiarity with types of construction in their community is an important tool in safely fighting fires. Every structure, commercial or residential, has their own unique situation, and fire departments cannot rely solely on the last fire incident they participated in to provide them with a plan that will work at the next incident. Proper training is an important aspect of safe fire

ground operation. Both officers and fire fighters must be aware of different types of building construction and their associated hazards.<sup>17, 18, 33</sup> For example, collapsing roof systems can exert pressure on supporting exterior walls, increasing the potential for wall collapse. Light weight roof truss systems pose a greater risk of collapse when damaged and/or exposed to fire. Different roof systems may collapse at different rates.<sup>33</sup> While heavy timber roof systems will withstand more degradation by fire than lightweight engineered roof trusses, both types are subject to failure.<sup>28</sup> Different phases of the fire suppression activities, such as the initial, offensive, and defensive attacks, and overhaul will have different hazards. However, the potential for collapse exists in any fire-damaged structure.<sup>33</sup>

This building construction knowledge begins with an initial fire fighter recruit school or other type of training module(s). The initial building construction knowledge progresses with additional training and experience gained through on-the-job training and/or individual walk through/preplan activity during and after construction. One source of information related to structural collapse hazards is the National Institute of Standards and Technology, Building and Fire Research Laboratory (NIST / BFRL). A DVD containing videos and reports related to structural collapse can be obtained from the NIST website <u>http://www.bfrl.nist.gov/</u>. <sup>34</sup> The NFPA 5000 *Building Construction and Safety* Code has specific information on all building construction and types. This information can be used to design and develop training curriculums for building construction.<sup>35</sup>

Fire departments cannot rely on the structure to not collapse. Fire departments should constantly be evaluating their fireground strategy and tactics and observing potential indicators of collapse (e.g., time exposed to fire, construction type, noises, and cracks). Fire departments must ensure that fire fighters, officers, and incident commanders have a sound knowledge base and experience that they can apply to any incident, allowing them to adjust it to meet the changes of the incident at hand. This department had limited documented training and no operating procedures for different types of building construction and safety factors associated with each type.

# Recommendation #9: Fire departments should ensure that a separate incident safety officer (ISO), independent from the incident commander, is appointed at each structure fire with the initial dispatch.

Discussion: According to NFPA 1561 *Standard on Emergency Services Incident Management System*,<sup>30</sup> The incident commander shall have overall authority for management of the incident and the incident commander shall ensure that adequate safety measures are in place. This shall include overall responsibility for the safety and health of all personnel and for other persons operating within the incident management system. While the incident commander is in overall command at the scene, certain functions must be delegated to ensure adequate scene management is accomplished.<sup>30</sup>

According to NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*,<sup>5</sup> as incidents escalate in size and complexity, the incident commander shall divide the incident into tactical-level management units and assign an incident safety officer (ISO) to assess the incident scene for hazards or potential hazards. These standards indicate that the incident commander is in overall

command at the scene but acknowledge that oversight of all operations is difficult. Although, the presence of a safety officer does not diminish the responsibility of individual fire fighters and fire officers for their own safety and the safety of others, on-scene fire fighter health and safety is best preserved by delegating the function of safety and health oversight to the ISO.

NFPA 1521 *Standard for Fire Department Safety Officer* defines the role of the ISO at an incident scene and identifies duties such as recon of the fireground and reporting pertinent information back to the incident commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective communications; and ensuring established safety zones, collapse zones, hot zones, and other designated hazard areas are communicated to all members on scene.<sup>36</sup> The ISO adds a higher level of attention and particular expertise in analyzing safety hazards, building construction, fire conditions, and in the particular uses and/or limitations of protective equipment, which will help fire fighters and fire officers.<sup>15</sup> Larger fire departments may assign one or more full-time staff officers as safety officers who respond to working fires. In smaller departments, every officer should be prepared to function as the ISO when assigned by the incident commander. When the designated ISO is not immediately dispatched or available at the scene, the IC should appoint an ISO. Line officers should receive sufficient training to act as an ISO where needed, until the designated ISO arrives on scene. This will ensure the presence of an ISO on the fireground at all times. The ISO should also be added to the first alarm of a reported fire and for additional incidents that the fire department sees necessary.

Additionally, the IC relies upon fire fighters and the ISO to relay feedback on fireground conditions in order to make timely, informed decisions regarding risk-versus-gain and offensive-versus-defensive operations. The safety of all personnel on the fireground is directly impacted by clear, concise, and timely communications among mutual aid fire departments, sector command, the ISO, and the incident commander.

The following recommendations are added as additional safety measures fire departments should take to support fire fighter safety and health.

# Recommendation #10: Fire departments and dispatch centers should ensure that emergency traffic over a radio, such as a Mayday, is effectively monitored, receiving the highest priority during an incident.

Discussion: NFPA 1221 recommends the communication center have the ability to monitor tactical fireground radio traffic.<sup>31</sup> Fireground communications can become very hectic and confusing when a fire fighter is in distress, becomes lost, or is trapped. Fire departments and dispatch centers must be able to effectively monitor radio transmissions (e.g., Maydays) while on the fireground and within a dispatch center. A Mayday procedure can outline the fireground response plan and duties of fire fighters, officers, the dispatch center, and the IC. This can include establishing separate radio channels for fireground operations, search and rescue operations, and/or water supply. This will help reduce any confusion during the Mayday.

The term "Mayday" is the international distress signal. Fire fighters must act promptly when they become lost, disoriented, injured, low on air, or trapped. <sup>37-42</sup> They should announce, "Mayday-Mayday" over the radio and manually activate their PASS device. A transmission of the Mayday situation should be followed by the last known location of the fire fighter and, if able, the individual's identifier (e.g., E3 pump). A crew member who suspects a fire fighter(s) is in trouble or missing should quickly try to communicate with the fire fighter(s) via radio and, if unsuccessful, initiate a Mayday providing relevant information.

An emergency radio transmission reporting a "Mayday" is the highest priority transmission that may occur at any incident and should receive precedence from dispatch, the IC, and other units operating at the incident. When this emergency traffic is initiated, all other radio traffic should stop to clear the channel and allow the message to be heard. Mayday transmissions must always be acknowledged and immediate action taken. The IC must either personally handle the situation or designate another officer to do so. Part of handling a Mayday is to communicate with the fire fighter(s) in distress and with any other fire fighters or officers involved. The sooner the IC is notified and a RIT is activated, the greater the chance of the fire fighter being rescued. If there is any question that a Mayday may have been transmitted and heard by someone (not all), priority should be given in verifying if it were a Mayday transmission. The IC should be made aware of this immediately, so that he can attempt to contact the individual who potentially transmitted the Mayday or contact dispatch to verify the transmission. A possible Mayday transmission should never be overlooked.

This fire department had not established a Mayday procedure that could be used as a training guide for fire personnel and guidance for dispatchers. Once a procedure is in place, the challenge for fire departments is providing realistic, safe training that accurately simulates fire conditions. It is absolutely necessary that the Mayday training place fire fighters in positions that closely simulate an actual fire to realistically exercise one's Mayday skills.<sup>42</sup>

In this incident, the victim was identified as missing after fire fighters escaping the collapse went directly to the IC to advise him that the victim was unaccounted for. Fire fighters went in different directions to search for the victim and dispatch was made aware of the missing fire fighter. However, radio communications regarding tankers and apparatus placement continued on the same incident channel as the search for the victim was being conducted.

Fire departments should be aware of the 2010 International Association of Fire Chiefs' (IAFC) *Rules of Engagement (ROE) of Structural Firefighting.*<sup>3</sup> These guidelines recommend that fire fighters constantly monitor fireground communications for critical radio reports and declare a Mayday as soon as they are in danger. Although not addressed by the IAFC ROE, ICs and dispatch centers should also be constantly monitoring fireground communications for critical radio reports.

Also, the IAFF *Fire Ground Survival* program was developed to ensure that training for Mayday prevention and Mayday operations is consistent between all fire fighters, company officers, and chief officers.<sup>42</sup>

# Recommendation #11: Fire departments should ensure that Mayday training program(s) are developed and implemented so that they adequately prepare fire fighters to call a Mayday.

Discussion: The first and foremost priority for fire fighter safety is not getting oneself into a situation that could potentially cause injury or death. The fire fighter must maintain situational awareness at all times while operating on the fireground. Knowledge and skill training on how to prevent a Mayday situation and how to call a Mayday should begin and be mastered before a fire fighter engages in fireground activities or other immediately dangerous to life and health environments. Beginner fire fighter training programs should include training on such topics as air management; familiarity with an SCBA, a radio, or PPE; crew integrity; reading smoke, fire dynamics, and fire behavior; entanglement hazards; building construction; and signs of pending structural collapse. If a fire fighter does find themself in a questionable position (dangerous or not), they must be able to recognize this and be trained on procedures for when and how a Mayday should be called. A fire fighter's knowledge, skill, and ability to declare a Mayday must be at the mastery level of performance. This performance level should be maintained throughout their career through training offered more frequently then annually.<sup>42</sup>

Fire departments must understand that each fire fighter may have a different interpretation of what is life-threatening. The ability of a fire fighter to call a Mayday is a complicated behavior that includes the affective, cognitive, and psychomotor domains of learning and performance.<sup>43</sup> Any delay in calling a Mayday reduces the chance of survival and increases the risk to other fire fighters trying to rescue the downed fire fighter. This incident illustrates the need for fire fighters to be given specific Mayday procedures for when a Mayday must be called.

There are no rules on when a fire fighter must call a Mayday, and Mayday training is not included in the NFPA standard for fire fighter qualifications, it is up to the authority having jurisdiction to train members for emergency operations.<sup>5,44</sup> It is up to each authority having jurisdiction to develop rules and performance standards for a fire fighter to call a Mayday. The National Fire Academy (NFA) has two courses addressing the fire fighter Mayday doctrine: Q133 Firefighter Safety, Calling the Mayday, a 2-hour program covering the cognitive and affective learning domain of the fire fighter Mayday doctrine; H134 Calling the Mayday: Hands-on Training, an 8-hour course covering the psychomotor learning domain of the fire fighter Mayday doctrine. These courses are based on the military methodology used to develop and teach ejection doctrine to fighter pilots. A training CD is available to fire departments free of charge from the U.S. Fire Administration Publications Office. <sup>43, 45</sup> The NFA Mayday courses present specific Mayday parameters or rules for when a fire fighter must call a Mayday. The courses may help fire departments in developing and teaching Mayday procedures for fire fighters.

Also, the IAFF *Fire Ground Survival* program is another resource fire departments can use and was developed to ensure that training for Mayday prevention and Mayday operations are consistent between all fire fighters, company officers, and chief officers.<sup>42</sup>

# Recommendation #12: Fire departments should ensure that a rapid intervention crew (RIC) is readily available and prepared to respond to fire fighter emergencies.

Discussion: A RIC should be designated and available to respond before interior attack operations begin and throughout the duration of the incident. The team should report to the IC and maintain position in a location that promotes rapid access to the structure if a Mayday is declared. When standing by, the RIC should monitor radio traffic and continuously size-up the incident and not assist in regular fire fighting activities. NFPA 1500, section 8.8.7 states, "At least one dedicated RIC shall be standing by with equipment to provide for the rescue of members that are performing special operations or for members that are in positions that present an immediate danger of injury in the event of equipment failure or collapse.<sup>5</sup> The RIC should have all tools necessary to complete the job: e.g., search and rescue ropes, combo Halligan bar and flat-head axe, first-aid kit, and resuscitation equipment.<sup>28</sup> These teams can intervene quickly to rescue a fire fighter who is running out of breathing air, disoriented, lost in smoke-filled environments, trapped by fire, or involved in structural collapse.<sup>5</sup> During this incident, there was no established RIC prior to the collapse within the sanctuary.

Fire departments should be aware of the 2010 International Association of Fire Chiefs' *Rules of Engagement of Structural Firefighting*. These guidelines recommend that ICs always have a rapid intervention team in place at all working fires.<sup>3</sup> Also, NFPA 1407 *Standard for Training Fire Service Rapid Intervention Crews* provides basic training procedures for fire service personnel to conduct fire fighter rapid intervention operations.

# Recommendation #13: Fire departments should ensure that incident commanders and fire fighters understand the influence of ventilation on fire behavior and effectively coordinate ventilation with suppression techniques to release smoke and heat.

Discussion: Ventilation is the systematic removal of heated air, smoke, and fire gases from a burning building and replacing them with cooler air.<sup>28</sup>The two types of ventilation are vertical and horizontal. During vertical ventilation the natural convection of the heated gases creates upward currents, which draw the fire and heat in the direction of the vertical opening. Horizontal ventilation allows for heat, smoke, and gases to escape by means of a doorway or window but is highly influenced by the location and extent of the fire, and special caution should be taken if the fire is in the attic.<sup>28</sup>

Properly coordinated ventilation can decrease the rate the fire spreads, increase visibility, and lower the potential for flashover or backdraft. Proper ventilation reduces the threat of flashover by removing heat before combustibles in a room or enclosed area reach their ignition temperatures. Proper ventilation can reduce the risk of a backdraft by reducing the potential for superheated fire gases and smoke to accumulate in an enclosed area. Properly ventilating a structure fire will reduce the tendency for rising heat, smoke, and fire gases, trapped by the roof or ceiling, to accumulate, bank down, and spread laterally to other areas within the structure. The ventilation opening may produce a chimney effect, causing air movement from within a structure toward the opening. These air movements help facilitate the venting of smoke, hot gases and products of combustion but may also cause the fire to grow in intensity and may endanger fire fighters who are between the fire and the ventilation opening.

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• Where to ventilate?

What type of ventilation?

- Why ventilate?
- How to properly and safely ventilate?

affect ventilation and overall control of the fire:

• What are the expected results from ventilation?

Who will ventilate (knowledge and skills)?

Fire development in a compartment may be described in several stages, although the boundaries between these stages may not be clearly defined.<sup>28</sup>The incipient stage starts with ignition, followed by growth, fully developed, and decay stages. The available fuel largely controls the growth of the fire during the early stages. This is known as a fuel-controlled fire, and ventilation during this time may initially slow the spread of the fire as smoke, hot gases, and products of incomplete combustion are removed. As noted above, increased ventilation can also cause the fire to grow in intensity as additional oxygen is introduced. Effective application of water during this time can suppress the fire but if the fire is not quickly knocked down, it may continue to grow.

If the fire grows until the compartment approaches a fully developed state, the fire is likely to become ventilation controlled. Further fire growth is limited by the available air supply as the fire consumes the oxygen in the compartment. Ventilating the compartment at this point will allow a fresh air supply (with oxygen to support combustion), which may accelerate the fire growth, resulting in an increased heat release rate. If coordinated fire suppression activities do not quickly decrease the heat release rate, ventilation induced flashover can occur.<sup>28</sup> Considering that most fires beyond the incipient stage are or will quickly become ventilation-controlled; changes in ventilation are likely to be some of the most significant factors in changing fire behavior.

During this incident, the ventilation hole was cut behind where the fire fighters were working interiorly (at the initial entry point). The idea of the trench cut in this application was to stop the fire from spreading from the sanctuary into the connecting hallway, when in fact this ventilation hole with the wind conditions drew the fire through the common attic space shared by the sanctuary and connecting hallway.

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For this reason, ventilation should be closely coordinated with hoseline placement and offensive fire suppression tactics. Close coordination means the hoseline is in place and ready to operate, so that when ventilation occurs, the hoseline can overcome the likely increase in combustion. If a ventilation

opportunity to extinguish the fire. If the opening is made elsewhere, the chimney effect may actually contribute to the spread of the fire.<sup>28</sup> ICs and fire fighters must consider the following and how it will

opening is made directly above a fire, fire spread may be reduced, allowing fire fighters the

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## **Investigator Information**

This incident was investigated by Stacy C. Wertman and Stephen T. Miles, Safety and Occupational Health Specialists with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. This report was authored by Stacy C. Wertman. An expert technical review was provided by John Tippett, Deputy Chief of Operations for the City of Charleston Fire Department. He is a 37 veteran of the fire service. Chief Tippett spent 34 years with the Montgomery County (MD) Fire and Rescue Service, retiring as the department's safety battalion chief in 2009. He has been involved in a number of fire fighter health and safety initiatives over the last decade including: introducing crew resource management to the fire service and working intimately with the IAFC's National Fire Fighter Near-Miss Reporting System. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

# **Additional Information**

#### IAFC Rules of Engagement for Firefighter Survival

The International Association of Fire Chiefs (IAFC) is committed to reducing firefighter fatalities and injuries. As part of that effort the nearly 1,000 member Safety, Health and Survival Section of the IAFC has developed DRAFT "Rules of Engagement for Structural Firefighting" to provide guidance to individual firefighters, and incident commanders, regarding risk and safety issues when operating on the fireground. The intent is to provide a set of "model procedures" for Rules of Engagement for Structural Firefighting to be made available by the IAFC to fire departments as a guide for their own standard operating procedure development.

http://www.iafcsafety.org/downloads/Rules\_of\_Engagement

#### IAFF Fire Ground Survival Program

The purpose of the International Association of Fire Fighters (IAFF) Fire Ground Survival Program is to ensure that training for Mayday prevention and Mayday operations are consistent between all fire fighters, company officers and chief officers. Fire fighters must be trained to perform potentially life-saving actions if they become lost, disoriented, injured, low on air or trapped. Funded by the IAFF and assisted by a grant from the U.S. Department of Homeland Security through the Assistance to Firefighters (FIRE Act) grant program, this *comprehensive fire ground survival training program* applies the lessons learned from fire fighter fatality investigations conducted by the National Institute for Occupational Safety and Health (NIOSH) and has been developed by a committee of subject matter experts from the IAFF, the International Association of Fire Chiefs (IAFC) and NIOSH. http://www.iaff.org/HS/FGS/FGSIndex.htm

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Diagram 1



**Diagram 2** 



Diagram 3



Diagram 4